

Remedial Investigation/Feasibility Study for the 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 Operable Units

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Contractor for the U.S. Department of Energy
under Contract DE-AC06-08RL14788

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Executive Summary

This document presents the results of a *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA)¹ Remedial Investigation (RI)/Feasibility Study (FS) undertaken for a portion of the Hanford National Priorities List² (NPL) Site referred to as 100-D/H. 100-D/H represents areas impacted by nuclear operations at the D, DR, and H Reactor Areas. The area has been organized into the 100-DR-1, 100-DR 2, 100-HR-1, and 100-HR 2 source operable units (OUs) and the 100-HR-3 groundwater OU. Site investigation and risk assessment work conducted for these OUs has resulted in a determination that contaminants in the vadose zone and groundwater pose a threat to the environment and a CERCLA remedial action is warranted. Based on the 100-D/H RI/FS, the Proposed Plan issued by the U.S. Department of Energy, Richland Operations Office (DOE-RL) identifies a preferred alternative, as well as other alternatives considered for cleanup of the 100-D/H OUs, in order to receive comments from the Tribal Nations and the public. A Record of Decision (ROD) will be issued that identifies the final remedial alternative selected for 100-D/H and provides a responsiveness summary for Tribal Nations and public comments. Remedial actions will address the integrated cleanup of contaminated waste sites and groundwater caused by releases from reactor operations. The objective for the remedial actions is to protect human health and the environment, including restoring groundwater to drinking water standards and achieving water quality criteria in the Columbia River that are protective of aquatic life.

This RI/FS, which supports the Proposed Plan, has the following objectives for the 100-D/H Area:

- Provide information concerning the physical environmental setting.
- Draw conclusions concerning the nature and extent of contamination present and the potential for migration of contamination.

¹ *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*, 42 USC 9601, et seq., Pub. L. 107-377, December 31, 2002. Available at: <http://epw.senate.gov/cercla.pdf>.

² 40 CFR 300, "National Oil and Hazardous Substances Pollution Contingency Plan," Appendix B, "National Priorities List," *Code of Federal Regulations*. Available at: <http://www.gpo.gov/fdsys/pkg/CFR-2010-title40-vol27/xml/CFR-2010-title40-vol27-part300-appB.xml>.

- Evaluate the potential for adverse effects on human health and the environment if no action is taken and exposure occurs.
- Develop and evaluate an appropriate range of remedial action alternatives to address unacceptable risk to human health and the environment.

This RI/FS was prepared based on information gathered from historical studies, investigations, process knowledge, data collected during implementation of interim actions, and recent field investigations. Soil and groundwater assessments and cleanup actions have been performed at 100-D/H since the early 1990s. The recently completed RI work was conducted to provide information to supplement the considerable body of information previously collected regarding site contamination. The supplemental RI work included excavation of five test pits, installation of 17 groundwater monitoring wells, and completion of 10 soil borings/temporary groundwater monitoring wells. Each of these activities included collection and analysis of samples to resolve data needs identified in the 100-D/H Work Plan³. In addition, a network of wells was sampled to determine spatial and temporal variations in groundwater contamination.

100-D/H Background

The 100-D/H Areas encompass 20 km² (7.8 mi²) adjacent to the Columbia River in the northern portion of the Hanford Site. This section of the Columbia River is within the Hanford Reach, which is a free-flowing section of the river that extends from Priest Rapids Dam downstream to the slack waters of Lake Wallula, formed by McNary Dam. Hanford Site cultural resources are diverse, ranging from early prehistoric times to the Atomic Age. The Hanford Site contains some of the most important archaeological sites in the region. Cultural resource surveys are routinely conducted as part of site evaluations to protect culturally sensitive areas. The results of these surveys are used in planning appropriate remedial actions.

The 100-D/H Area includes three deactivated nuclear reactors and support facilities that produced plutonium from 1945 to 1967. The reactors were built to irradiate uranium fuel rods to produce plutonium and other special nuclear materials. The reactors and processes

³ DOE/RL-2008-46-ADD1, 2010, *Integrated 100 Area Remedial Investigation/Feasibility Study Work Plan, Addendum 1: 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 Operable Units*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: <http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0084374>.

associated with operations generated large quantities of liquid and solid wastes. Waste generated from reactor operations was contaminated with radionuclides, hazardous chemicals, or both. Solid wastes included sludge, reactor components, and various other contaminated items associated with reactor operations. Solid waste was generally placed in burial grounds. Liquid wastes were released to the environment by discharging effluent to temporary surface impoundments, cribs, ditches, trenches, and the Columbia River.

During operations, the 100-D/H Area included 128 facilities such as storage buildings, offices, retention basins, maintenance shops, process plants, an electric substation, storage tanks, pump stations, and outfall structures. The aboveground portions of these facilities were removed under separate regulatory decisions and are not addressed in this RI/FS.

Physical/Environmental Setting

The topography at 100-D/H is relatively flat inland from the Columbia River; elevation changes are greatest near the Columbia River, where the riverbank slopes steeply. The semiarid climate has occasional high winds, and the majority of the land surface is an undisturbed shrub-steppe community. Riparian areas immediately adjacent to the river shoreline represent unique ecological communities.

The Hanford formation is the dominant material in the vadose zone (unsaturated zone) and consists of a sand and gravel unit that increases in thickness away from the river. Groundwater in the unconfined aquifer is predominantly within the Ringold Formation unit E in the 100-D Area and predominantly within the Hanford formation in the 100-H Area. The unconfined aquifer in the Horn Area between 100-D and 100-H transitions from predominantly Ringold Formation unit E to the Hanford formation. The changing river levels influence groundwater elevations close to the river with decreasing effects inland. Groundwater flow direction is normally toward the river, except when the river is high, which causes groundwater to flow in a direction away from or parallel to the river.

The conceptual site model includes consideration of the physical and chemical characteristics of vadose materials, geologic features of the area, local groundwater characteristics, and the interaction of these elements with the Columbia River. The characteristics of the study area influence the movement of contaminants within the environment.

Nature and Extent of Contamination

This document describes the current distribution of contaminants in environmental media, predicts the migration rate of contaminants through the physical setting (fate and transport), and evaluates the potential for contaminants to enter the Columbia River.

Discharges of large volumes of liquid effluent to the vadose zone during reactor operations contributed to significant alterations in local hydrologic conditions and resulted in the accelerated transport of contaminants to deeper portions of the vadose zone and unconfined aquifer groundwater in 100-D/H. Contaminant migration rates are currently much slower than during operating periods because those discharges have stopped.

Contaminants identified in the vadose zone include radionuclides, anions, organic chemicals, and metals. The analytical results from the RI characterization indicated the localized presence of hexavalent chromium [Cr(VI)] in the vadose zone.

There were 343 sites identified in the 100-D/H Area. These sites were evaluated using the Tri-Parties site evaluation process for determining the status of each waste site. Forty-eight sites were closed out, rejected or not accepted as waste sites. Three of the waste sites are the deactivated D, DR, and H Reactors. The reactors are addressed under a different ROD, and are not the subject of this document. The 100-D-58 waste site was a septic tank and leach field that has been closed under Washington State Department of Health regulations. The remaining 291 waste sites are evaluated in the RI/FS to determine the need for remedial action. The waste sites in 100-D/H included storage tanks, ponds, trenches, cribs, French drains, solid waste burial grounds, retention basins, pipelines, and spills/leaks.

Waste site remedial actions in 100-D/H began in 1995 under an interim action ROD⁴ and are ongoing. Interim action waste site cleanup consists primarily of removing and disposing of contaminated material followed by backfill and revegetation. These cleanups will continue until a new ROD is issued.

Cr(VI) is the most widespread contaminant in groundwater beneath 100-D/H. Other groundwater contaminants are total chromium, strontium-90, and nitrate. Chromium is

⁴ EPA/ROD/R10-95/126, 1995, *Interim Remedial Action Record of Decision for the 100-BC-1, 100-DR-1, and 100-HR-1 Operable Units, Hanford Site, Benton County, Washington*, U.S. Environmental Protection Agency, Region 10, Seattle, Washington. Available at: <http://www.epa.gov/superfund/sites/rods/fulltext/r1095126.pdf>.

collocated with the Cr(VI) plume. Strontium-90 is present in the groundwater in relatively small, localized areas. Nitrate is present over larger areas, but within boundaries of the Cr(VI) plume.

Groundwater cleanup was initiated in 1997 under an interim action ROD⁵ with the startup of the first pump-and-treat system. An interim action ROD amendment⁶ in 1999 approved installation of an in situ redox manipulation barrier as a new technology for treating Cr(VI)-contaminated groundwater in the 100-D Area. The initial two pump-and-treat systems were expanded under an interim action ROD ESD⁷ to provide additional treatment capacity. Two treatment systems currently operate to remediate the Cr(VI) plume and protect the Columbia River. The Cr(VI) concentrations and plume footprint areas in groundwater are declining.

Exposure Assessment

Scenarios of how human and environmental receptors might come into contact with contaminants, with resultant health impacts, were evaluated. The principal contaminants identified in the soil associated with waste sites include radionuclides, metals, polychlorinated biphenyls, and polycyclic aromatic hydrocarbons. The risk assessment identified chromium, Cr(VI), nitrate, and strontium-90 as the principal groundwater contaminants. Potential remedial technologies in the FS mitigate these soil and groundwater contaminants.

Of the 291 waste sites evaluated in the RI/FS, there were 146 waste sites in 100-D/H with closeout verification data collected following the implementation of interim actions that were quantitatively evaluated. Soil screening levels (SSL) and preliminary remediation goals (PRG) were established for the environmental media of interest (soil and groundwater), type of contaminant (hazardous substances and radionuclides), human and ecological receptors, and potentially complete exposure pathway. The SSLs and PRGs are based on updated U.S. Environmental Protection Agency (EPA) guidance and a conservative scenario that includes assumptions of vadose zone contamination (100:0 initial source distribution model for low distribution coefficient [K_d] contaminants and

⁵ EPA/ROD/R10-96/134, *Record of Decision for the 100-HR-3 and 100-KR-4 Operable Units Interim Remedial Actions, Hanford Site, Benton County, Washington.*

⁶ EPA/AMD/R10-00/122, 1999, *Interim Remedial Action Record of Decision Amendment for the 100-HR-3 Operable Unit, Hanford Site, Benton County, Washington.*

⁷ EPA et al., 2009b, *Explanation of Significant Differences for the 100-HR-3 and 100-KR-4 Operable Units Interim Action Record of Decision: Hanford Site, Benton County, Washington.*

70:30 initial source distribution model for high K_d contaminants) and an infiltration/recharge rate based on irrigation scenario for SSLs and conservation land use for PRGs.

Alternatives Development

The FS portion of the RI/FS consists of four phases: development of remedial action objectives (RAOs), screening of remedial technologies, development of remedial alternatives, and detailed analysis of alternatives. Remedial technologies were assembled into alternatives that address contamination on a media- or source-specific basis.

RAOs for groundwater, surface water, and soil are general descriptions of what a proposed remedial action is expected to accomplish. RAOs are narrative statements that define the cleanup required to protect human health and the environment. The RAOs generally include information on the media, contaminants, receptor, exposure pathway, and remediation goals.

A range of general response actions to meet RAOs is identified for the vadose zone and groundwater contaminants of concern (COC). Response actions include different technologies and process options identified for the vadose zone and groundwater. The process options and technologies are evaluated for relative effectiveness, implementability, and cost.

The remedial technologies retained from the screening process were combined into remedial alternatives to provide a range of technologies for integrated waste site and groundwater remediation. The remedial alternatives were developed to achieve the RAOs and be responsive to National Contingency Plan⁸ (NCP) and CERCLA programmatic goals. Alternatives evaluated include:

- Alternative 1 – No Action (required by the NCP)
- Alternative 2 – RTD and Void-Fill Grouting for Waste Sites and Pump-and-Treat with Biological Treatment for Groundwater
- Alternative 3 – RTD and Void-Fill Grouting of Waste Sites and Increased Capacity Pump-and-Treat for Groundwater

⁸ 40 CFR 300, "National Oil and Hazardous Substances Pollution Contingency Plan," *Code of Federal Regulations*. Available at: <http://www.gpo.gov/fdsys/pkg/CFR-2010-title40-vol27/xml/CFR-2010-title40-vol27-part300.xml>.

- Alternative 4 – RTD for Waste Sites and Pump-and-Treat for Groundwater

Alternatives Evaluation

Alternatives were evaluated individually and comparatively against the CERCLA threshold and balancing criteria. Threshold criteria include overall protection of human health and the environment and compliance with applicable or relevant and appropriate requirements. The balancing criteria include: long-term effectiveness; reduction of toxicity, mobility, or volume (TMV) through treatment; short-term effectiveness; implementability; and cost. Modifying criteria include state and community acceptance. The Washington State acceptance modifying criteria has been addressed by state support for issuance of this RI/FS report and the 100-D/H Proposed Plan. The remaining modifying criterion, community acceptance, will be evaluated after the Proposed Plan goes through the Tribal Nations and public comment process as reflected in the responsiveness summary that will be included in the 100-D/H CERCLA ROD.

The purpose of the detailed and comparative analysis is to develop the information necessary to recommend a preferred alternative in a Proposed Plan. The analysis showed:

- Alternative 1 - No Action does not meet threshold criteria for all sites.
- Alternative 2 - RTD and Void-Fill Grouting for Waste Sites and Pump-and-Treat with Biological Treatment for Groundwater meets threshold criteria, performs well for long-term effectiveness, reduction of TMV, and short-term effectiveness, and less well for implementability.
- Alternative 3 - RTD and Void-Fill Grouting of Waste Sites and Increased Capacity Pump-and-Treat for Groundwater meets threshold criteria, performs well for long-term effectiveness, reduction of TMV, short-term effectiveness, and implementability.
- Alternative 4 - RTD for Waste Sites and Pump-and-Treat for Groundwater meets threshold criteria, performs well for long-term effectiveness, reduction of TMV, and implementability, and performs less well for short-term effectiveness.

The alternatives perform equally for long-term effectiveness and permanence. Alternatives 2 and 3 perform better than Alternative 4 for reduction of TMV, and Alternative 3 is expected to perform better than Alternatives 2 and 4 for short-term effectiveness. Alternative 4 is rated highest for implementability. Costs are the lowest for

Alternative 2 and the highest for Alternative 4. The analysis presented in this RI/FS provides enough information to be able to recommend a preferred alternative in the Proposed Plan.

DOE will develop and submit for Ecology approval a new remedial design report/remedial action work plan (RDR/RAWP) and groundwater monitoring plan, prepared in accordance with the Tri-Party Agreement (*Hanford Federal Facility Agreement and Consent Order* [Ecology et al., 1989a]) for the final remedy selected. All future remedial actions will then be performed under the approved RDR/RAWP. All 291 waste sites will be included in the ROD for the final remedy decision to be documented, even if no further remedial activities are needed.